TITLE OF THE INVENTION

Shock absorbing support system

BACK GROUND OF THE INVENTION

-Field of the invention

The present invention relates to the significant reducing of the dynamic loads produced by earthquake, vibration, or collision. The present invention prevent structure failures for subjects, such as electrical boxes on top of bridges, or any important instruments that subject dynamic loads induced by earthquake, truck traffic, sudden acceleration or collision.

-Description of the related art including information

BRIEF SUMMARY OF THE INVENTION

Since vibrations created by the heavy trucks, earthquakes, vibrations, or collisions induce significant dynamic force to the supports of an object; an isolation supporting system is proposed to reduce the dynamic impact to the supporting system and instrument itself. The system is isolated through four spring supports from bottom of the object.

At the same time, dampers are attached between the supporting structure and the instrument vertically and horizontally. The functions of the dampers are to convert the kinetic energy of the system to the heat energy through a special liquate confined inside of the dampers. The manufacture claims that the damper can create 50% of the damping factor. The dynamic loads of the object are substantially reduced by the combination of spring and damper system.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The invention is better understood by reading the following Detailed Description of the Preferred Embodiments with reference to the accompanying drawing figures, in which like reference numerals refer to like elements throughout, and in which:

FIG. 1 illustrates a front elevation view of the shock absorbing support system with springs and dampers at bottom and dampers at the top portion according to the present invention.

FIG. 2 illustrates a side elevation view in cross-section of the shock absorbing support system with springs at bottom and damper at the top portion.

FIG. 3 is a schematic damper location plan, top view of the shock absorbing support system.

FIG. 4 is a schematic spring and damper location plan, bottom view of the shock absorbing support system.

FIG. 5 is an enlarged elevation view of damper and spring assemble at the bottom support.

FIG. 6 is an enlarged elevation view of damper assemble at the top support.

FIG. 7 is an enlarged view of the spring assembles in FIG. 1.

FIG. 8 is an enlarged view of the damper assembles in FIG. 1.

FIG. 9 is an enlarged view of the damper support in FIG. 1.

FIG. 10 is an enlarged view of the pin and retaining ring for the damper support in FIG. 1.

Fig. 11 is a flow chart of model analysis

DETAILED DESCRIPTION OF THE INVENTION

In describing preferred embodiments of the present invention illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the invention is not intended to be limited to the specific terminology so selected, and it is to be understood that each specific element includes all technical equivalents, which operate in a similar manner to accomplish a similar purpose.

Referring initially to FIG. 1, a preferred embodiment of the shock absorbing support system is shown. Vertical members 7 sit on a horizontal member 8 that is fixed attached to a structure that has vibration source. Horizontal members 6 sit on the vertical members 7. The horizontal members 6 function as a platform that supports the instrument 3. The vertical upper members 4 are fixed attached to the horizontal members 6. Rigid frame 5 functions as a cage that hold the instrument 3. Between the frame 5 and horizontal platform, springs 1 and dampers 2 isolate the instrument 3 from the support 7 and 8. Upper end of members 4 are connected to upper portion of frame 5 through several dampers 2.

In the FIG. 2, a preferred embodiment side elevation of the shock absorbing support is shown. Vertical beams 7 sitting on horizontal member 8 support the platform 6. Springs 1 isolating instrument 3 from the vibration source are guided through steel rods 20. Steel rods 20 prevent instrument 3 vibrate erratically without restrains. Vertical dampers 2 at the bottom support of instrument 3 convert vertical kinetic energy of the vibration into

heat energy dissipated to the surrounding atmosphere. Thus the vertical load from instrument 3 transfer back to the supporting system is significantly reduced. Horizontal dampers 2 at the top portion of instrument 3 connecting instrument 3 to vertical members 4 convert the horizontal kinetic energy into the heat energy dissipated to the surrounding atmosphere. Thus the horizontal load from instrument 3 transfer back to the supporting system is significantly reduced.

FIG.3 shows a preferred embodiment with schematic location of top horizontal dampers 2 in two directions of horizontal plain. Horizontal dampers can transfer horizontal vibrating energy (kinetic energy) into heat energy from any horizontal direction in this configuration. There are no dampers 2 at front face 10 of instrument 3 because instrument 3 can be removed or installed from the system. At back face 9, dampers 2 are attached to instrument 3. Two section views are shown in FIG. 1 and FIG. 2.

FIG. 4 shows a preferred embodiment with schematic location of bottom vertical dampers 2 and springs 1 at each bottom corner of instrument 3. Vertical springs 1 isolate the system from the vibration source and support the weight and dynamic load of instrument 3. Vertical dampers 2 can transfer vertical vibrating energy (kinetic energy) into heat energy in this configuration. Two section views are shown in FIG. 1 and FIG. 2.

Members 6 provide a platform for springs 1 and dampers 2. In FIG. 5, bottom of steel rods 20 are welded to members 6. Spring coils 21 are placed around steel rods 20 as shown in FIG. 7. Top of steel rods 20 is free standing. Plate 14 welded to member 12 of

instrument rigid frame 5. A hole in the center area of plate 4 is large enough to let steel rods 20 through and some room for lateral movement. Steel nuts 23 lock steel rods 20 after steel rods 20 go through the hole of plate 14.

By the side of springs 1, dampers 2 are connecting members 6 and members 12 through damper mounting assemblies 10. Damper mounting assemblies 10 are welded or bolted to members 6 and members 12. Dampers 2 are pined to damper mounting assemblies 10 by pin assembles 31. Pin assembles 31 are composed of steel rods 51 with two recesses for retaining ring at each end and locked by retaining rings 52 in FIG 10.

FIG. 6 shows a preferred assemble of horizontal dampers 2. Damper mounting assemblies 10 are welded or bolted to members 4 and members 41. Members 41 are part of rigid frame 5. FIG. 8 shows a typical damper, which is preferred to be manufactured by Taylor Devices Inc. FIG. 9 shows a preferred damper mounting assemblies 10. Damper mounting assemblies 10 are composed by steel u frame 30, two shim plates 32, and pin assembles 31.

The requirement for a dynamic analysis often leads to a direct need by the engineer for a sophisticated general-purpose computer software system such as GTSTRUDL. GTSTRUDL permits the engineer to utilize all of the member, finite element, graphical display, and steel design features available in static analysis in conjunction with the dynamic analysis capabilities in those structures subjected to strong wind, seismic, heavy truck traffic, or vibrating machinery loadings. Using combinations of these features,

dynamic analysis results may be obtained for a large variety of structures and loading conditions.

The dynamic analysis of the shock absorbing support system can best be summarized by FIG. 11. First geometry (Joint coordinates) 101 of the system is input into the computer. Topology (member and finite element incidences), support boundary conditions, member and finite element boundary conditions, material properties, and member and finite element properties 102 are also needed for the input. Dynamic information, such as structure damping and dynamic loadings (time history or spectrum) 103, may be collected from the field or from lab experiment. If the dynamic loading is from time history, it can be converted to spectrum 104.

Static loads 108 are inputted to perform static analysis 109. The static analysis result 112 can be outputted independently from dynamic output 107. With dynamic data 103, computer first perform eigensolution without initial stress 105, then dynamic analysis through one of the following method: (1) Response spectrum analysis (Including Missing Mass, Base Shear, and Shear Wall Analysis calculations) or (2) transient time history analysis 106. After the dynamic analysis 106, the program creates pseudo static loading 111 results from dynamic analysis results. Dynamic analysis results such as dynamic data output, eigensolution results output, response spectrum analysis results output and transient analysis results output 107 can be outputted independently. Program combines static analysis result 112 and dynamic analysis results 107 into shock result 113. After the combination, program also can perform member design and/or code checking 114.

The dynamic analysis is based on the following theories. The dynamic equilibrium equation may be written in the following matrix form:

$$[M]\{a\} + [C]\{v\} + [K]\{x\} = \{F(t)\} \qquad (1\text{-}1)$$

where [M], [C], AND [K] are matrices representing the mass, damping, and stiffness of the structure, respectively. The vectors {a}, {v}, and {x} represent the acceleration, velocities and displacement of the joint degree of freedom. The vector {F(t)} represents the applied transient forces.

Response spectrum analysis is an approximate method of dynamic analysis that uses the know response of single degree of freedom systems with the same natural frequency and percents of critical damping as the modes of vibration of the structure being analysis when subjected to the same transient loading.

For applied support acceleration,

$$\{F(t)\} = -[M]\{E\}\, a_G(t) \qquad (1\text{-}2)$$

Where,

$a_G(t)$ is the time dependent support acceleration

{E} is a vector containing one's for degrees of freedom in the direction of the applied ground motion and zeroes otherwise.

Then

$$\{a_t(t)\} = \{a(t)\} + \{a_G(t)\} \qquad (1\text{-}3)$$

Where,

$a_t(t)$ contains the total acceleration where the subscript t indicates total

$a(t)$ contains the nodal point acceleration relative to the supports

Therefore,

$$[M]\{a_t\} + [C]\{v_t\} + [K]\{x_t\} = -[M]\{E\}\, a_G(t) \qquad (1\text{-}4)$$

As in the modal analysis method, the equation of motion must be uncoupled and transformed to normal coordinates for the response of each mode to be calculated. In a modal time history analysis, Eq. 1-4 would be solved in order to evaluate the response at each time step. However, in a response spectrum analysis, it is assumed that we know the maximum value of the integrals from either previous computation or experimental results.

Once the maximum response for each mode is obtained, the maximum total response must be computed. GTSTRUDL computes response spectra maximum response by combining the modal responses by seven different approaches. These seven methods are root mean square, absolute summation, peak root mean square, complete quadratic combination, nuclear regulatory commission grouping method, nuclear regulatory commission ten percent method, and nuclear regulatory commission double sum method. Each of the seven combination techniques may be performed for each response spectra loading condition. In addition, the root mean square method may be used to combine the results of two or more response spectra loadings, which may represent statistically independent dynamic components.

An instrument with 800 pounds of static load was modeled with vibration generated by heavy truck load using this shock absorbing support system. A model without this system

is also analyzed. The next table shows the juxtaposition of two models. It demonstrates the system with dampers and springs has significant advantages over the model having no dampers and springs.

COMPARISON OF RESULTS

Model	w/ springs and dampers	w/o springs and dampers
Acceleration At vertical direction	148.5 in/sec^2	614.64 in/sec^2
Acceleration At horizontal direction	60.5 in/sec^2	250.4 in/sec^2
Velocity At vertical direction	8.9 in/sec	11.69 in/sec
Velocity At horizontal direction	5.7 in/sec	4.76 in/sec
Max. stress of support member	0.168 ksi	3.9 ksi
Max. dynamic force of support member	176 lbs	703 lbs
Max. dynamic force at each VMS box support	102 lbs	356 lbs